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SEQUESTRATION ANÆMIA IN BRAIN AND SKULL SURGERY.

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Of all the operative causes of shock, admittedly the first and chief is haemorrhage. Indeed, it has been said by able clinicians that shock is only another name for haemorrhage.*

The older a surgeon the greater becomes his respect for a drop of blood.

It seems strange that careful as we all are to apply this principle in cutting work upon the limbs, it has apparently been overlooked (as to cordage) elsewhere. For example, prior to any bloody operation whatever upon an extremity, we elevate and accumulate in the trunk, neck and head, by gravity, and sometimes also by centripetal massage, most of its blood; and then by cordage near the trunk maintain anæmia during the cutting. But what surgeon about to operate on however vascular a field of the head, the neck or the body, ever applies this same principle—and to avoid haemorrhage accumulates blood in the extremities? Nobody, for this purpose, so far

* Crile on Surgical Shock, p. 138. (Explaining, however, that in reality haemorrhage may be only one important factor in shock causation.)

as I am aware. And yet if wise in the one instance it is (at least as to preventing bleeding) obviously so in the other. To be sure we cannot deprive the other parts of blood to anything like the same degree that we employ in dealing with the members. Nevertheless, experience shows that we can with entire safety withdraw into the limbs some quarts of the whole bulk which constitutes one-thirteenth of the individual's weight. We can sequestrate before operation and retain in the limbs by cordage enough to make a striking difference in loss of blood from the operative field; enough, indeed, as the writer has convinced himself, to constitute in many cases the difference between life and death, between shock and absence of shock, in a gravely severe case.

This temporary bleeding, so to call it, into the patient's own extremities, is controlled as to degree, by the finger of an assistant upon the pulse. Its original volume and force being estimated, the sequestration proceeds until there is a plainly noticeable softening and lessening of tension. At this point begins the operation; and every cut vessel spurts less than otherwise would be the case. Indeed, were we unwise to carry the plan to its limits, hardly any haemorrhage would occur, but the patient's heart would beat so feebly as to cause him to faint away. Many a case, for instance, of attempted suicide from cut-throat has lived because of this, firm clotting occurring meanwhile at the mouths of the severed vessels. And as to effect upon respiration, this is proportionate to the extent of the bleeding, whether actual or into the patient's limbs, the breathing being always both accelerated and deepened.

But of course no such extreme is advised; simply a noticeable degree of pulse softening. If we reduce by even a moderate amount the quantity of blood otherwise surely lost, the gain in safety is obvious. Should the anæsthetist observe a tendency toward cardiac weakness it is easy almost instantly, by release of cordage, to produce a distinct improvement both as to force and number of heart beats.

This report is in the nature of a preliminary one. I am

experimenting as to whether by the circumference of the limbs taken before accumulation and again later on we can estimate the relative amount of blood withdrawn. It is possible that by testing the blood-pressure before and after withdrawal into the limbs, using by choice the Riva Rocci apparatus with Cushing's improvements, the assistant may reach more accurate estimates than thus far have been attained. However, in no case out of many (including therein work upon the neck, chest, abdomen and pelvis, as well as a much smaller number upon the skull), has the writer thus far cause to regret using the plan. It is not, then, because of simply theoretical advantages that it is now brought forward, but because it has practically been found a means of safeguard and reliance. And it can now be spoken of in terms which at first would not have been justifiable.*

The technique is as follows: A towel folded lengthwise is wrapped about each thigh very close to the trunk, and upon this the rubber tube is tightened. The towel serves in a measure to prevent subsequent discomfort, by spreading the pressure over a wider area. The degree of tightness is quickly learned by practice. It must nearly stop the venous but not the arterial current. Quickly the limb distal to the tourniquet grows dusky in color and there is obvious swelling also. After from five to ten minutes, according to the tightness of the cord, the softened pulse will indicate that we are ready to proceed with operating. The congested limbs are, however, first warmly wrapped, and hot-water bags placed about them.

In case the effect of the major anaesthesia is feared, in a given instance, these steps may be taken with a conscious patient, in order to form a reserve-guard of pure blood. And if then during operation failing respiration or other cause seem to justify it, removal of cord and elevation of limb or

* The writer distinctly states that he makes no claim for originality as to cording for the arrest of *accidental* haemorrhage, either surgical or medical. As to the latter he would again call attention to a much neglected subject. See his paper in the Proceedings of the Surgical Society of the New York Academy of Medicine, Nov. 9, 1891.

limbs will pour quarts, literally, of fresh blood into the narcotized, and the patient will awaken almost at once.* But as a rule, to avoid discomfort, nothing is done until the subject is asleep.

When at first the writer began experimenting in blood sequestration a less simple plan was thought essential. Two limbs being swollen, the cord was tightened so that no further blood could enter, nor any escape. So far as a study of literature could guide, no ease was discovered where absolute stagnation of healthy blood within a healthy limb for as short a period as a half hour had been followed by gangrene; but for safety, after fifteen minutes (if the operation must be longer) the assistant, trained to this purpose, began cording the remaining two limbs, almost at the same time commencing to release those first constricted; and in a long operation this shifting from arms to thighs, and back again, was done repeatedly. But after a time it seemed that we might obtain equally good results with less trouble; and since then the tube has been left so placed, as to degree of tension, that continually some blood enters—for the pulse is not wholly shut off—and of course some blood also escapes into the trunk. Only in case the limbs grow excessively swollen, or the pulse demands a change, is the tension altered during the operation. In a few plethoric individuals I have used constriction of all four extremities at once in this way. But generally cording the lower ones only—at the groin—has sufficed to accomplish much good in the way of blood saving.

Obviously, the ultimate return of so much blood into the general circulation ought not to be accomplished instantly. For the sake of the heart, the cords should be loosened rather slowly, taking nearly as long to release as to accumulate the blood.

* Of course for this purpose the idea is not at all new. It was first suggested (*re anaesthesia*, by Dr. David Webster in the N. Y. Med. Journal in 1887, and was tried by the writer within a month later. See also Atlanta Med. and Surg. Journal, Aug., Sept. and Oct., 1897,—articles upon Anaesthesia.

The question naturally arises at this point whether, as this is done, the restoration of the usual pressure will not be accompanied by so much spurting from a myriad cut vessels—if the field be large—that finally little would really be gained in saving of blood. Undoubtedly this would be the result if nothing further were to be suggested. But as a regular part of the procedure under discussion we must, before releasing the tourniquets, clot firmly the blood in the mouth of every divided vessel by the following step—*to be considered the necessary corollary of what has gone before, and always to be used after it.* I refer to an application of gauze sponges wrung dry, with the rubber-gloved hand, out of actually boiling water brought at this moment to the operating table. Not “hot” water, but water at 212 degrees F. No one need fear ill results to even the most delicate tissues of the human body from a few seconds’ firm application of gauze at this degree of heat—the brain perhaps excepted.* And, in consequence, not only is bleeding prevented, but the entire raw surface turns white from coagulated albumen, sterilizing it if it was not sterile before. And thereafter, if contaminated by ichorous

* The author has not as yet tested upon animals’ brains the effects of brief contact at a boiling temperature; but as to nerves has done so, and they are not injuriously affected, if only a few seconds elapse in such contact. It was only after such experimentation that the following operation was performed. Upon October 11, 1906, at Dr. John A. Wyeth’s clinic at the N. Y. Polyclinic Medical School the author excised from the left side of the neck of a man of thirty a cancerous growth so extensive as to require the removal, in the mass, of practically the entire length of the deep jugular vein. The pneumogastric nerve was saved. During manipulation several suppurating lymph-nodes ruptured, infecting the large wound, which was first cleansed by irrigation as usual, then dried, and filled for fifteen seconds with water actually boiling when taken from the fire, across the room. As in the dog, so here, an instant effect was noticeable. The patient’s breathing was made much deeper and more rapid; also the heart’s force was distinctly increased and the frequency was somewhat lessened. These effects upon the pneumogastric were observable for from three to five minutes. The wound was closed except for a narrow gutta-percha tissue drain introduced at the lowest point through a counter opening above the shoulder; and it quickly healed by primary union throughout. No subsequent adverse effect upon the nerve was observable. In repeated cases the writer has used the steaming

pus or septic fluids from the mouth or bladder, for instance, we are reasonably safe from danger of extension of such infection—very much as the surgeon feels regarding such a risk when once his wound is covered with healthy granulations.

Of course it is necessary, in order to prevent blisters, to avoid contact with skin or mucous surfaces. And obviously a very long application might, so to speak, cook the flesh. But used as advised, the writer has never had cause to be other than pleased with the result of employing this very old but much neglected application of heat.

Since atmospheric pressure makes such a difference in the temperature of boiling water, at high altitudes such as Denver it would be necessary for the best results to use water heated under pressure.†

Among the advantages of sequestration surgery (if I may use this term, simply to avoid a long periphrasis, whenever in this paper I must refer to it) in brain work its striking lowering of intracranial pressure is not the least. Where a brain tumor is to be operated upon, for one example among a num-

gauze pressed for a few seconds—or even boiling water—in direct contact with the deep jugular vein; the youngest, a baby of a year old, immediately following removal of tuberular lymph-nodes; this was a patient of Dr. William A. Ewing, of this city, who assisted. There were no objectionable results; the venous current was too rapid to permit of heat clotting—and the infected wounds healed per primam.

In the pneumogastric case just discussed the author ended by doing his starvation operation (excision of the external carotid and its branches, with paraffin plugging of the terminal two).

Dr. Wyeth, who was present, remarked to the class of graduate students, that for the kind and size of operation the wound had been drier—there had been less bleeding—than he had ever seen before. This we quote simply as bearing upon the technique under discussion, for this operation was done with corded lower limbs.

† It may be suggested that heat so employed may well take the place of Harrington's fluid, as sealing cut lymphatics and bloodvessels without use of irritant chemicals. Also prior to use of Mosetig Moorhof's bone-cavity filling, it will stop bleeding without harm—instead of the use of dry air at burning temperature pumped in, which risks superficial necrosis from the presence of a red-hot point close to or within the bone cavity, meanwhile. Of course the cavity must next be carefully dried, before introducing Moorhof's filling.

ber, a great risk of sudden death is thus avoided. To quote Sir Victor Horsley *: "Moreover, all cases of increased intracranial tension (as is now well recognized) are liable to die at any moment of sudden paralysis of the respiratory centre. How often one sees this accident in cases of intracranial tumor who are only at the very last transferred for surgical treatment!" Crile,† too, names excessive intracranial pressure first among causes of collapse due to injuries or operations affecting base of brain and medulla.

Horsley objects to ether because it invites more haemorrhage in brain operation. And yet, though advocating chloroform, admits its greater toxicity to nerve-tissue. He adds: "In the literature of the early days of cerebral surgery may be found instances of death upon the operating table, which I have no doubt were due to failure of the respiratory centre owing to a dose of chloroform having been given which, though perhaps not necessarily lethal in an ordinary case, was fully so to a patient whose bulb was hampered by previous tumor pressure." It must be obvious that the plan we are herein advocating is a distinct safeguard to some degree against the danger mentioned from each of these drugs, and from pressure. And, conversely, in brain operations where already the pressure is dangerous (as in instances just quoted) Crile's pneumatic suit would obviously add to the risk unless indeed both of the common or the internal carotids be controlled as he suggests.

It is important in connection with Horsley's paper to note his method (*loc. cit.*) of treatment of haemorrhage during brain work of the kind chiefly annoying—venous and capillary oozing, due to chloroform asphyxia, which raises the intravenous pressure—he adds a stream of oxygen to his chloroform vapor. "It is interesting," he says, "to see how rapidly the bleeding stops as the color of the oozing blood changes from dark purple to bright scarlet. I frequently, therefore, during operation, especially toward the end, request

* British Med. Journal, Aug. 23, 1906.

† Surgical Shock, p. 151.

the anæsthetist to turn on the oxygen for this purpose as well as for the elimination of shock."

For this interesting and valuable discovery we are thankful; but as to the following from the same paper, it is perhaps not beyond a mild criticism: "When the brain is obviously turgid with congestion I always ask that the chloroform percentage should be raised for, say, a quarter to half a minute, to one or two per cent. This at once induces a convenient, proportionate, and of course temporary anæmia" (by causing a fall in blood-pressure). Plainly, as sequestration does the same thing, we have in it "the ounce of prevention," and no need to push chloroform at all.

In controlling arteriole and capillary brain haemorrhage, Horsley's favorite plan is hot water irrigation at a temperature "which should not exceed 115° F. nor fall below 110° F." He fears that if 120° be used, heat coagulation of the cut surface of the brain would result.

During a very recent visit to the Mayos at Rochester, Minn., the writer found Dr. Charles Mayo employing what is in effect the same idea as his own, in otherwise very bloody work upon head or neck. He employs *gravity* sequestration, however, instead of cordage. His patient is seated in a nearly upright posture, and Dr. Mayo stands upon a stool in order to be high enough to reach the field of operation. Obviously if there are any objections to be offered to the plan by sequestration they apply equally here; but Dr. Mayo has had no reason to regret adopting this idea. However, were chloroform to be the anæsthetic chosen, the upright attitude would self-evidently be unsafe because of its effect upon the heart. It is for this reason that its employment by dentists in the dental chair has been followed by fatalities not otherwise explicable.

In addition to Horsley's and Mayo's ideas as to control of haemorrhage in this operative field we must refer to the recent suggestion of Dr. George W. Crile, in his paper read at Boston last June, in which he advocated in addition to "a head-up inclined posture," and his rubber pneumatic suit, exposing

and applying temporary clamps to the common carotids; to be released as soon as the operation is completed. This last he also suggested in his work upon Blood Pressure.*

Thus far we have said nothing regarding a question which has doubtless occurred to all—namely, does sequestration-anaemia threaten shock?—depriving as it does, however, temporarily, the brain and heart of a considerable part of the blood.

The answer, based upon more than two years of trial in my practice, and covering many regions of head, neck, and trunk, is in the negative.

In all that we do as surgeons we are always selecting the lesser of (at least) two evils; and although—stated as a general principle—it seems desirable to keep the vasotonic centre well supplied with blood, yet there is evidence at hand that in numerous instances so brief a partial anaemia as that during an operation is well borne; and that, as compared with avoidable loss of considerable blood, in these instances the sequestration constitutes the lesser evil.

* Dr. Crile says in this essay (*Journ. Am. Med. Assoc.*, Dec. 1, 1906): "In 61 cases I have temporarily closed the common or external carotid without immediate or remote consequences."

This leaves us in the dark as to their relative frequency. It is surprising that so serious and so safe a vessel should be classed together in this indifferent way. Even temporary closing of the common—but long enough for the extensive operation required in radical cancer work in the neck—I should consider not justifiable when the same result, namely a dry operation, can be obtained in a less questionable way.

Not long since Dr. Charles Mayo remarked that in the neck there are just two structures which he holds in implicit respect and lets alone. One of these is the parathyroid bodies—the other, the common carotids of the elderly (which is the age requiring cancer operation). Dr. John A. Wyeth in his Am. Med. Assn. Prize Essay puts the mortality from closing of the common carotid at 40 per cent. Of course, however, this does not mean temporary clamping.

But as to such clamping, or even definitive ligation, of the *external* carotid, this is a measure as wholly devoid of risk as anything surgical can well be. I say this after using it about seventy-five times, of which more than fifty are given in detail (thus excision of this vessel) in my Gross Prize Essay, which upon p. 105 discusses this question. To speak as Crile does of it, as having a mortality rate of 2 per cent. from the washing away of the thrombus of the ligated stump *causing cerebral*

Indeed, if we reflect upon the main causes of operative shock, it is demonstrable that sequestration helps to a marked degree to prevent each of these. Omitting psychic causes, also needless rough handling, and the obvious fact that it follows work in certain regions more than in others, there may be said to be four main sources of shock due to surgery. These are: (1) Bleeding; (2) length of operation; (3) excess of major anaesthesia; (4) loss of vital heat.

As to the first of these, the advantage from sequestration has to be seen to be believed. The difference between excision of the upper jaw, for instance, accomplished with this step, and the same without, would be convincing enough in itself.

(2) As to length of operation, certainly a dry field has everything to do with this.

(3) Major anaesthesia, as every surgeon knows, is an important cause both as to depth and duration; and if, as will be proven by histories adduced herewith, in a brain operation, for example, the patient once under will, at least in some cases, remain so for long periods, just from anaemia similar to that in natural sleep, we have eliminated, in every minute so devoid of drugging, just so much risk of shock.

embolism, is simply to state an anatomical impossibility, as it does not supply the brain. Other writers have made the same curious error. I do not doubt that the occasional deaths with brain symptoms following supposed ligations of this vessel have been due to the commonest of its numerous anomalies, and the one which is the rule in dogs, namely, that there was no external carotid, or one insignificant in size, but that instead the internal, on its way to supply the brain and eye, gave off in the neck all the branches usually derived from the external carotid. (See author's Gross Prize Essay, pp. 142-143, also Chapter VII.)

I have myself cost the life of one of my earliest cases by this very blunder, with its resultant extreme anaemia of the brain. I tied, above the level of the common carotid that vessel which when controlled stops pulsation both in the facial and superficial temporal arteries; but this, the customary test, is unfortunately not at all reliable.

There are but two which are trustworthy: (1) finding a frank bifurcation of the common carotid; and (2) instant contraction of the pupil on the ligated side, where this precautionary search has been neglected, when it may not be too late to undo the damage by promptly cutting the ligature. Also, this second test can be used, doubtless safely, by intentional stoppage of circulation with the finger-tip and noting the effect, or absence of it, upon the pupil.

(4) As is well known, ether and chloroform reduce temperature markedly. Hare has shown that ether very quickly brings it down two degrees Fahrenheit below normal. Consequently, by cutting off necessity for prolonged breathing of ether we prevent this factor in shock.*

However, should any indications threatening shock appear—such as undue rapidity, weakness or irregularity of rhythm of pulse—it would be as simple as possible to end them by releasing one or both tourniquets; doing it gradually, to give the heart a little time in which to meet its added duty.

ILLUSTRATIVE CASES.

CASE I.—*Excision of Cerebellar Tumor.* This was a farmer, Mr. A. A. K., at 60, married, denies history of venereal. A patient of Dr. E. A. Schnell, of Round Hill, Conn. This patient seen, and subsequently operated upon, at his home in the country, Vallhalla, N. Y., gave the following history: For the past six months, at least, he had complained of headache of increasing severity, located in his occiput, right side, low down. This was accompanied by an increasing inability to walk, due chiefly to dizziness. His stomach was upset, and he had frequent attacks of projectile vomiting. Also his sight was rapidly failing.

This made a picture so indicative of cerebellum tumor that I advised calling in the services of Dr. James A. Meeks, an oculist, who reported choked disc, and advised in favor of immediate operation.

This was performed on May 10, 1905, by the writer, assisted by Prof. George F. Shiels, formerly of the University of California, and by Drs. W. L. Griswold and John A. Clark, of Greenwich, Conn. Ether was the anesthetic employed. With the trephine followed by the Devilbiss rongeur a large aperture was made exposing the right lobe of the cerebellum. An indurated portion of this was located, not encapsulated, and extending so far as the test by needle could determine, over an area of irregular contour, but perhaps involving one-third of this half of the

* Dr. R. C. Kemp's suggestion of keeping the rectum and colon filled with very hot normal salt solution during operations in general, using his rectal tube and an irrigator, deserves a more thorough trial than it has received.

hind brain. All this indurated portion was excised. It proved to be a glioma. The patient had hardly any bleeding, thanks to the accumulation of blood in his lower limbs; and, what surprised us all, once asleep he needed no more ether during all the time of operation—just three-quarters of an hour. He lay sleeping quietly, without stertor, and quite as if the natural anaemia existent during normal sleep were the determining factor in that condition rather than an artificially produced anaemia.

His recovery was without incident; and accompanied by a rapid improvement in all his symptoms. But when about a month had elapsed and he was once more up and about, in passing a catheter to relieve a prostatic congestion which troubled him occasionally, he infected himself; and the cystitis rapidly spread up the ureters, causing "surgical kidneys" and prompt death from suppression.

This outcome is recorded to give a full report; but surely the case may properly be classed as a success so far as the reason for operation is concerned; as also regarding the value of the method by cordage.

As to the advantage of avoidance, because of this, of the need for prolonged exhibition of ether or chloroform, when one reflects upon the usual risk of haemorrhage from the delicate leptomeningeal vessels during the cerebral congestion accompanying vomiting after brain operations, and of hernia cerebri from bursting of the sutures in the dura, from the same cause, prevention of these risks seems indeed a distinct gain.

Regarding the duration of this operation without fresh anaesthesia and yet without pain or returning reflexes, for three-quarters of an hour of operation, we recognize of course that work upon any portion of the encephalon, once the dura is penetrated, is painless, except in the tract of any of the sensory cranial nerves, or along the course of the fillet. Perhaps brain work in a sensitive region would have compelled resumption of the anaesthetic sooner. But the longest period during which Sir Victor Horsley, for example, has been able to operate upon a cerebellar growth without necessity for renewal administration of the anaesthetic has been twelve to fifteen minutes

(loc. cit.). In the final case recorded in this paper the same complete success as to anaesthesia will be found noted. It has also been observed in other than head operations.

Though this was by no means an early instance of my employment of sequestration, it was the first in brain-work, and the earliest in which it occurred to me to try whether the moderate brain-anæmia might not suffice to maintain operative analgesia—once the patient was fully narcotized as usual.

CASE II (Operations 2 and 3).—Trehinining for Extradural Haemorrhage. Mr. F. S., American, æt. 30; telegrapher, single, denies venereal history. First seen by the writer November 21, 1905, in his service at the City Hospital, twelve days after receiving a single severe blow upon the right side of the head from a club. No clear history obtainable as to his condition during the interval between the injury and admission—except that he complained of much headache and seemed increasingly stupid. Those about him were very unobservant people. When attention was first drawn to him he had a temperature of 102° F., rectal, and he was suffering from severe clonic convulsions, chiefly of his entire left side; to a lesser degree also upon his right half. He was wholly unconscious, and had gradually become unable to be aroused, during the past three days of the twelve. Both eyes were directed sharply toward his right; pupils equal and of normal size. Had a moderate degree of Cheyne-Stokes respiration. The shaven skull presented evidence of but one wound, quite superficial and partly healed. This was about 5 cm. in length and situate over the middle of the right Rolandie fissure.

Evidently this man was suffering from pressure upon his brain; and the temperature of 102 led me to the erroneous diagnosis that we should find as cause, between dura and skull, the products of inflammation—fibrin, serum and pus. Instead, nothing was there but a large clot from rupture of the middle meningeal. And slowly the bleeding had increased the pressure until the convulsions, etc., appeared.

In a recent article upon brain surgery Dr. M. Allen Starr* in discussing extra dural haemorrhage asserts without qualification

* Jour. Am. Med. Assn., Sept. 22, 1906.

that the symptoms develop within six hours after the injury. Here is a case infinitely slower; and I have operated upon several where a few days had elapsed. It is plain that the time is dependent chiefly upon (a) the size of the broken arteriole and (b) upon what region of dura is being stripped up. In the temporal fossa this membrane is least firmly attached to the bone. Starr, in the same article, considers that when the hemiplegia, for instance, "does not come to its height for three or four days it is probable that there is a *surface haemorrhage* due to the injury of a vein of the pia mater. A lumbar puncture will reveal bloody cerebro-spinal fluid." As stated, I am convinced that hemiplegia so developing in point of time would more often be explained as just mentioned. However, certainly lumbar puncture would be of unquestionable value simply in confirming a diagnosis of haemorrhage; although the indication to enter the skull promptly for relief of pressure would exist equally in either case.*

Regarding the question at which probable level beneath the skull a surgical haemorrhage has occurred, perhaps it may be of interest to note how wide a difference of opinion is found even among surgeons of wide experience. From without inward:

(I) Deaver asserts † that all cases seen by him have been subcranial—(*i.e.*, between dura and skull); and he adds that so easily is the dura of the temporal fossa separated from its bone that, given a ruptured branch of the middle meningeal, this will happen without any fracture whatever.

(II) *Subdural* (*i.e.*, between dura and arachnoid). According to the English surgeon, Prescott Hewitt, this is the commonest variety.

(III) *Subarachnoid* (and into the meshes of the pia mater). Erichsen states that the commonest variety is at this level. (I do not imagine that it is possible to differentiate, practically, (II) from (III), and probably Hewitt and Erichsen mean one and the same thing.)

(IV) Into the substance of the brain or its ventricles; *i.e.*, true apoplexy. Unquestionably the rarest of these four, as a result of traumatism.

* Blood-tinged cerebro-spinal fluid withdrawn by lumbar puncture is a valuable sign of fracture at the base of the skull.

† Phila. Med. News, Feb. 15, 1890.

Returning to our patient. Operation, under ether, assisted by the House Staff, November 21, within an hour after the case was reported to me. Cordage for sequestration. Incision upon his right. Upon exposure of the bone, an undepressed fracture was at once evident, beginning slightly lower than the level of the skin abrasion, and extending roughly along the Rolandic line, and thence steadily downward and forward across the base of the skull further than could be followed. On removal of bone with the Devilbiss rongeur, a very extensive and thick bloodclot was exposed—plainly the source of the left hemiplegic convulsions. Its upper part was quite firm and partly organized, more so than that lying at the base, and which latter was evidently more recent. Irrigation alone was ineffective; nothing short of the blunt curette sufficed to break up and dislodge the clot. Much bone had to be sacrificed to get room to do this work; and for this the temporal muscle was split clear down to the zygoma and its edges widely retracted. The handle of the curette was bent nearly to a semicircle, to permit scraping away the thick clot which was continuous right across the base, and even then its limits could not be reached. From some point at the very base blood welled up at the seat of fracture, as soon as the clot was dislodged there. This was controlled by packing down against this point a thin strip of damp gauze well rubbed with glutol (formalin gelatin, powdered). This was removed five days later without starting up the bleeding (two attempts, one upon the third, one the fourth day had showed that we must still wait).

There was no recurrence of the left-sided convulsions; the temperature promptly fell to normal and remained so; and the patient became partly conscious, with eyes no longer turned toward his right.

However, forty-eight hours after the first operation, my house-surgeon, Dr. Thomas, reported by telephone that the man had begun to have severe clonic convulsions of his entire *right* side (it will be remembered that he had at first right-sided convulsions, but to a far less degree than upon his left), and a resumption of Cheyne-Stokes breathing. Within an hour thereafter I visited him, finding the seizure apparently nearly as bad as that upon the opposite side had been. This was to me most puzzling; however, the indication as to my duty was a plain one.

Accordingly, the patient being again anaesthetized, the left Rolandic area of the skull was this time exposed and penetrated; but although considerable bone was removed with the Devilbiss rongeur, no blood clot was found; nor did the flat end of a probe passed between bone and dura at various points reveal any. Nevertheless the dura bulged into the bony gap, and without its normal pulsation. (I subsequently noted, in other cases, that the accumulation of blood in the limbs regularly puts a stop, almost or wholly, to the customary brain-pulsation observed, otherwise, in normal cases at operation.) Upon turning up a flap of dura we now exposed, lying beneath it—between it and the arachnoid and pia—an extensive, thick, partly organized clot, firmly adherent, covering an area as large as the parietal bone, and to all appearances being as old as the one removed from about the same level upon the opposite side two days earlier. It was removed in the same way—by blunt curette and irrigation. Plainly this clot was the main cause of his right hemiplegic convulsions. But no discoverable fracture—not even a crack—existed upon this left side. It must be clearly remembered, in studying this most rare case, that whereas the clot was *external* to the dura upon his right, it was *internal* to the dura upon his left. Unless this is explicable as an example of that condition, "*contrecoup*," far more often written about than seen, the writer is unable to understand it. It seems probable that the extradural, basal bleeding re-started up at the first operation, as already chronicled, went on slowly beyond the point reached by the packing (which could only be extended to his left a little beyond the median line at the base); and spreading from below upwards, on his left, after the two days became—*plus* the large *subdural* clot—enough of a pressure-factor to have re-excited the right side convulsions, etc.

The recovery was ideal, and without incident. Three weeks later this patient was shown at a meeting of the Polyclinic Medical Society. At that time his faculties were entirely restored.

Regarding the bearing of these two operations on the special topic of this paper, all the staff noted with interest that, once under the anaesthetic, the patient slept quietly during the work upon both skull and clots, and only once or twice was a few drops more required. The first operation lasted fully an

hour; the second, about forty minutes. Also, it would seem probable that the accumulation of blood in the limbs aided clotting in contact with the gelatin-gauze, because of diminished blood-pressure at the bleeding point.

One deceptive sign in this patient—the temperature of 102° upon the twelfth day after the injury—is of interest. After barring out a rise of thermometer from infection of the superficial wound, should such be present—or from malaria, bronchitis, gastric catarrh, and from constipation—in a word, the usual causes, here remains a case requiring the opinion of an expert; and one of the neurologists to the hospital, Dr. Graeme M. Hammond, expressed the opinion that the fever was due to pressure-irritation of the thermotaxic centre.*

A case of this kind is distinctly encouraging as showing once more that a class of accidents—haemorrhage from fracture at the base, until recently not held operable—can sometimes be saved by active intervention.

Case III.—Trephining for Cerebral Cicatrix with Dural Adhesions. This patient is a young gentleman, F. B. R., Jr., age 18, who has been afflicted since the age of seven, at which time he fell from a height, fracturing the right side of his skull. Operation was required, and performed by a certain New York surgeon. During all the years between seven and eighteen this boy has been subject at times to the most violent fits of temper, though ordinarily of a most gentle and tractable disposition. Latterly he has taken to drinking heavily, and has developed a periodic dipsomania. Upon examination of the skull two wide scars, each of about a finger's length, crescentic in shape, and

* Dr. Willy Meyer, in the discussion following the reading of this paper, reported a case of his own during the past year, exactly parallel as to fever, and hence as to reason for supposing the hemiplegia to be due to pressure from products of inflammation—fibrin, serum and pus. But operation proved that the febrile temperature was caused only by a large blood clot beneath the skull. At a recent meeting of the N. Y. C. Surgical Society Dr. Meyer has recorded yet another instance of such deceptive rise—the case proving at operation to be aseptic. However, absorption of fibrin-ferment from the clot, or other quite usual causes of such rise would seem to explain it without need of the assumption given in the text.

roughly parallel with each other, indicate the fields of operation consequent upon the fracture in his childhood. The parietal boss was about midway between these scars. Under each of these broad cicatrices it was believed that the meninges were adherent to the brain, as a consequence of the original infective inflammation: for there was a history of prolonged suppuration before these semicircular wounds healed. For the past two to three years there has been frequent twitching of the fingers on the left—the side opposite these scars. His mother says there is never an hour when they are quiet, except when they are controlled by his will. This indicates cortical irritation in the region of the hand-centre in the precentral convolution. Operation was advised, to separate brain from an adherent dura mater, if nothing else should prove necessary. Consultation with Dr. Frederick Peterson resulted in receiving from him urgent advice to permit operation; not as definitely promising improvement, but as positively asserting a hopeless condition if operation should be refused. In other words, the knife was considered the lad's only chance, and a rather poor one at that.

Operation was performed by the writer in Dr. Bull's private hospital, December 6, 1905, assisted by Drs. John B. Walker, George F. Shiels, J. H. Waterman, A. L. Goldwater. Anæsthesia (ether) by Dr. Thomas Bennett. An incision was made to run midway between the two long and wide crescentic scars aforesaid and the skull was penetrated accordingly. With the Devilbiss rongeur an area of the dura as wide as the thumb was laid bare, and all these pieces were saved in warm, normal salt-solution. Just as anticipated, adhesions were found. In stripping these away from the brain the sound of the separation could be heard to the confines of the rather large room—an indication of their degree of firmness. It was at one time contemplated to prevent readhesions by leaving goldfoil or other smooth foreign material in place between brain and dura; but final reflection caused me to fear that even this might (upon this hypersensitive cortex) itself constitute, as a foreign body however smooth, a brain irritant. Instead, a thin layer of blood was allowed to form over this brain area and to clot firmly, before permitting the brain to come into relationship again with its dura. This was only possible by aid of the sequestration of blood in the limbs. Because of this the brain was found by no means fully filling its brain-ease;

the stripping was accomplished with a dull tool curved to follow the brain contour; and one could see to work within the curve of the calvarium far beyond what would have been possible, and with far less risk of brain-laceration, than if a similar tool had been passed, guided only by sense of feel, between a congested, full brain and its skull.

The brain-work being ended, it was thought best to replace the pieces of skull. Since they were so small and of exactly equal size, each compared with all the others, nothing can be more ideal than the Devilbiss rongeur for encouraging such bone-replantation. Between thirty and thirty-five pieces were fitted together upon the dura, when this had first been sutured, where divided, with size double 0 of chromicized catgut. All of these pieces lived, being nourished by capillarity. It is obvious that the smaller the pieces of tissue of whatever sort which we attempt to engraft—whether of bone or ovary or thyroid gland or whatnot—the better its chance of surviving. For, its blood vessels being clotted, nothing but capillarity can carry to its interior the vitalized plasma which alone must nourish it.

In this instance we forgot to test the point noted in previous skull cases—whether anaesthesia once accomplished might not have been maintained by the brain anaemia due to the cordage. However, Dr. Bennett was asked to watch for any adverse signs consequent upon the accumulation of blood in both thighs and legs, and he reported that neither pulse nor respiration was affected in the least adversely. Duration of operation, one hour.

The patient had an ideal primary healing, his scar being practically invisible. As to results, from the time he awoke again until to-day he has had no return of the twitchings of his hand, and he volunteered the statement that his head feels better and clearer than for years. However, after a few weeks he went upon a violent spree; and after trying hypnotic suggestion with only temporary benefit, and the Oppenheimer "cure" with none at all, he has now been sent upon a sea voyage to South Africa in a sailing vessel with a temperance skipper and with no liquor aboard. It is, I fear, easy to prophesy the ending of this most pitiful case—an only son of fine parents. Perhaps, had the operation in question been performed sooner, before the dipsomania showed itself, removal of the adhesions as a persistent cause of brain irritability might have effected a real cure.

CASE IV.—Trephining for Cerebral Cicatrix with Dural Adhesions. Miss O'C., a patient of Dr. J. D. Quackenbos, æt. 27, is brought with the following history. Since the age of eleven she has been an epileptic. In that year while swinging in a "seup" she fell, striking her head with enough violence against the corner of a house to render her unconscious. Her attacks at first, though irregular in interval, as always, were a month or less apart. For the past year they have much increased in frequency, latterly the worst being at night, and averaging perhaps a fit in each 24 hours. Her mental powers, always rather poor since the accident, have noticeably deteriorated of late. The attacks begin by a feeling of dizziness; if there is a true aura of any kind the patient is unable to describe it. She drops unconscious, kicking and making swimming motions with her upper limbs. Both sides are alike as to their involvement in the attacks. Menses regular and not painful.

An examination of the shaven scalp revealed an old cicatrix about 4 cm. long, over a depression of the skull, of nearly that extent, and of about 1 cm. depth, situate about 2 cm. above and to her left of the inion. This is where she was struck, as a child. Although this case is of a type of epilepsy offering little hope indeed from operation, when compared with the results of surgical intervention where the type is Jacksonian, yet it seemed quite likely that there was irritation from the depressed bone beneath the scar; and in any case, operation was urged by Dr. Quackenbos as being her only chance of help. Accordingly this was done at the Polyclinic Hospital, before the class, upon April 10, 1906. By use of the DeVilbiss trephine and rongeur all the bone involved was removed. Although there had been some depression of the inner table, this was less than of the outer, the diploe having been crushed compact at this point; and there was no evidence of irritation beneath the bone, no thickening nor exceptional adhesion of the dura, nor (tested by the flat end of a probe through a tiny slit in the dura) was there any brain adhesion beneath. Obviously, little improvement could be hoped for in consequence of our work. Because of the depression the pieces of bone were not replaced; and to protect the dura over the rather large bony gap, it was decided to use the special kind of celluloid plate recommended by the writer at the St. Paul meeting of the American Medical Association a few years ago; a

kind carefully deprived of all free nitric acid, and with a trifle of synthetic urea replacing the usual irritant and abundant camphor, to give resiliency. Such a plate, transparent, resembling a yellow window pane, has several advantages, into which I cannot go here. In this instance, fifteen minutes was the longest period during which the cording enabled the anæsthetist to discontinue chloroform. Once more it was noticed how satisfactorily dry was the operative field.

This patient's recovery was per primam. At this time, some seven months after operation, her mother reports that the attacks are somewhat milder and less numerous than before operation. However, such temporary improvement, due apparently to the vigorous counter-irritation as much as anything, often results from mere penetration of the skull.

CASE V.—Excision of Foot-Centre in Cortex for Relief of Jacksonian Epilepsy. Mr. C. R., is a patient of Prof. Grecie M. Hammond, in the City Hospital, New York, who refers him to me for operation. Age, 48; Ameriean; unmarried; occupation, driver; is a blond, fairly nourished but anæmic. Denies trauma, also venereal disease. Has had for seven years attacks of left-sided convulsions, at very irregular intervals of about two to three months, latterly rather more frequently, and coming on sometimes at night, which was not at first the case. Has long complained of headache over the right Rolandic area; no known cause for this. His attacks begin without aura, other than a severe dull headache for a half hour before an attack, the pain being in the right Rolandic region. Then comes twitching of the left great toe, spreading rapidly to foot, leg and thigh, to left side of body, arm, and finally to face; but he never loses consciousness. Great weakness of the muscles involved for some days afterwards.

Two years ago was operated upon by another surgeon, the scar being plainly visible. A large omega-shaped flap was then made and the skull opened accordingly. This was fully 6 cm. too far forward to expose the motor centre, and no good whatever was accomplished.

Upon December 17, 1906, I operated, in the presence of Profs. Hammond and George F. Shiels and Dr. Edwin Beer, and assisted by Dr. Wrenn, house surgeon, and the rest of the resident staff of the City Hospital. Dr. Dettweller, anæsthetist.

Dr. Shiels kindly took charge of the sequestration-work. This patient had a severe degree of mitral insufficiency, not well compensated by hypertrophy. Chloroform was tried at first. Being badly tolerated, ether was substituted. Operation about two hours long, due chiefly to annoying oozing from the cut edges of the dura, which proved three to five times thicker than normal, over the area exposed (right Rolandic). This bleeding was trivial in amount, but of course had to be wholly controlled before closing the wound; also, the dural upper surface had to be dried before, with a naked copper wire and weak Faradoid current, the foot centre could be located. This being indicated approximately, the dural flap was cut accordingly; firm adhesions were found, binding the brain and leptomeninges to the thickened dura, and were separated with some little difficulty. Next, the precise situation of the foot-centre was ascertained upon the naked brain, and excised, cutting out the entire thickness of gray cortex over a superficial area of about $1\frac{1}{2}$ cm. square. This centre was found, as expected, to extend beyond the top and to include the adjacent mesial part of the lobule. Just as a matter of interest the arm and hand centres were also located by the electric current, lying entirely anterior to the fissure, and between the centres governing the face and the trunk-muscles. To prevent re-adhesion a thin sheet of gutta-percha tissue was laid smoothly in place over the brain, covering the whole area exposed, and then the dura mater was sutured.* To allow relief from pressure upon the cortex by the thick dura, the skull was not replaced, but instead a slightly dome-shaped piece of the special celluloid mentioned in Case IV was inserted. This was of but half the entire thickness of the calvarium in this region, yet was very strong, rigid and smooth. It rested upon a narrow ledge of the vitreous table, the outer one having been chiselled away a trifle for this purpose.

Regarding the result of sequestration in this case, it was very unsatisfactory because of the man's heart disease. For several periods, of about seven minutes each, anaesthesia was withheld, but then had to be resumed. Probably without sequestration the same could have been done. As soon as the limbs became

* Prof. Hammond has seen the skull re-opened five years after such a gutta-percha tissue layer had been used, and states that it was found very full of holes; and evidently before much longer would have quite disappeared by absorption.

distinctly swollen the heart-beats mounted quickly to 130 or so, at which point, upon uncording, they dropped speedily to about 80. This was tried a second time, for purposes of study. Of course this operation was no fair test of sequestration; and this, too, was the reason of the long delay in checking the oozing from the dura. Were the blood not so actively flowing, the steaming gauze would have sealed the vessel-mouths promptly. Given an example of uncompensated valvular disease, we plainly have one of the instances—to be discussed later—where this operative aid (sequestration) is counterindicated.

Healing was by primary union throughout, in this patient's case, and without incident. As to the results of the foot-centre excision upon his epilepsy, Prof. Hammond's detailed report is not given herewith because it has no bearing upon surgical technique; but he expresses himself as well satisfied, and hopeful of a cure, so far as the interval of time since operation permits him to judge.

CASE VI (and last, making seven head-operations by the method under discussion).—*Excision of Hand-Centre in Cortex for Relief of Jacksonian Epilepsy.* Mr. D. E., is a patient of Prof. Graeme M. Hammond, in the City Hospital, New York, who refers him to me for operation. Age, 20; American; no occupation; single; denies venereal. He is short, dark, well-nourished, stupid in expression. At the age of four met with an accident, falling a short distance (unknown), striking upon his head. Doubtful whether this is important, for the convulsions began only at the age of nine. No other ascertainable cause. These occur from once to several times daily. They begin without aura, by twitching of the flexors of the left hand, spreading quickly up that arm and into the same side of the face. He is never unconscious because of them, but feels exhausted afterwards. His left hand and arm are distinctly smaller and weaker than his right; the hand-clasp about half that of the right. The left hand is always the colder also. He can use simple language coherently, but voluntarily mentions a failing memory; always poor but much worse of late. Is anxious for the operation advised by Prof. Hammond—though that gentleman has but slight hope of its effectiveness in this case.

Operation in the City Hospital December 31, 1906. Present: Prof. Hammond, and resident staff; Dr. Wrenn, house surgeon;

Dr. Dettweller, anæsthetist. Chloroform anæsthesia, under which the operation was begun; but it was discontinued, and thereafter (forty-five minutes) work continued, including exposure and cutting of dura, and its final suturing, with only the analgesia due to the sequestration, and without any restlessness or other indication of suffering.

The Rolandic area upon his right was marked out, an omega-shaped flap, including the bone, was lifted by aid of the Devilbiss rongeur, and attempts made to locate the hand-centre through the dura by the copper wire and very weak Faradaic current. So irritable was the entire motor area of his cortex, however, that wherever touched with the wire all the muscles of the opposite side responded. However, after some minutes of this testing, and doubtless excited by it, a convulsion occurred, lasting a few minutes, and exhausting thereby the excessive irritability; so that upon its cessation we were able without difficulty to locate the hand-centre, causing no twitching in muscles elsewhere. The dura being turned up, the centre was more accurately marked, and excised, taking out a square piece of the gray, down into the white, the entire transverse width of the precentral lobule; in dimensions about as in the previous case.

Nothing abnormal was noted at operation either in appearance of bone, dura, leptomeninges, or brain, in this patient. However, by microscope, the pathologist reports evidences, in the piece of cortex excised, of chronic abnormality in cellular arrangement. Details omitted as having no bearing upon surgery.

There remains one point of exceptional interest. During the cutting of the skull by the Devilbiss rongeur, along the terminal 4 cm. of this omega curve, the blade, which, travelling beneath the skull, should never penetrate the dura—and never has before, to my knowledge—in some way slipped through, and for this distance ploughed the brain-cortex. This caused bleeding, welling up from the cerebrum at points not possible of exact location. I did not wish to pack, neither to apply chemicals—other than adrenalin solution upon a narrow gauze strip tucked gently down into the brain tear—which, however, did not stop the flow at all. Finally, remembering that boiling water had not harmed the pneumogastric nerve in the case operated upon at Dr. Wyeth's clinic (see footnote earlier in this paper), I tried gauze wrung out of water at 212° F. and tucked down into the tear, as before.

This succeeded after several repetitions of a few seconds each. It apparently did no harm to the brain tissue, so far as the recovery is a guide. A narrow strip of gutta percha tissue, to prevent adhesion of the brain to the dura at this point, was smoothly laid down, and the dura was sutured above it. The bone-flap was replaced. After the dura was sewn the cording was released, taking five minutes; and now, after three-quarters of an hour without chloroform and without pain, the patient began to wake up. Healing was by primary adhesion, with no unpleasant features whatever.

This case is too recent to permit of decision as to whether the operation is going to be of permanent benefit to his epilepsy or not.

If we now discuss the counterindications to this, which for convenience has been called sequestration surgery, it will at once be seen that they are quite numerous, and that a reasonable degree of common sense must be employed in determining when to use and when to avoid it. Like every weapon in our armamentarium capable of good, it is also capable of harm, if turned against a patient by a surgeon gifted in that way. Let us study these points, concerning which I have much to thank my friend Dr. Boise, of Grand Rapids. His article upon "Post Operative Embolism" is an equally clear study of ante-operative thrombosis; or again, of the causes which during sequestration would operate to produce clotting of the comparatively quiescent blood. To study these in an orderly way, one may say that there are three: (a) changes in the blood, (b) changes in the vessel walls, and (c) changes in speed of current. The last would be unimportant without one or both of the first two named; for normal blood will not at all readily coagulate when held even without motion within normal blood-vessels, and in our technique a moderate degree of circulation is maintained throughout. In Bier's method of treating joint inflammation often the partial stasis by cording is kept up for a half day at a time, and, though hundreds of cases have been reported, so far without dangerous result. But given either unhealthy blood or blood vessels as a predisposing cause,

slowing the current would then act as an exciting one, and make sequestration dangerous from venous thrombosis and possibly subsequent pulmonary embolism.

To specify several blood-conditions of serious import, we name the following: Recent typhoid, or any other septic condition of the blood, such as puerperal sepsis not long past; chlorosis, and indeed severe anaemia of any sort; and the presence of lime-salts in excess. Haward* shows that the blood of typhoid convalescents is much more coagulable than normal, and that it contains twice as much lime salts; and implies that its increased coagulability is due to this last fact. Obviously, since increase of these salts invites clotting, and indeed since we use this knowledge in preparing patients for certain operations where there is likely to be troublesome bleeding, we must recollect not to do so if intending to employ sequestration.

As to diseases of the vessel walls, atheroma is an obvious counterindication. Of course yet others exist which we cannot stop to study at this time.

As tending to prevent thrombosis, it is interesting and soothing to remember that prolonged smoking markedly has this good effect. B. M. Richardson showed by experiment that after a long day's smoking the blood refused to coagulate at all, where in the same patient, blood drawn in the morning had clotted in two minutes.†

Aceepting Horsley's assertion, quoted earlier in this paper, it follows that the duskeness of the limb—the cyanotic or venous character of the blood held within it—would rather tend to prevent clotting; at least he strongly recommends arterializing the blood by oxygen, when very dark in color, as a means of causing coagulation when bleeding would otherwise continue. And yet Haward (*loc. cit.*) names carbonic dioxide among a list tending to *increase* coagulability of the blood, and oxygen as *decreasing* the tendency to clotting.

* Hunterian lecture, *Lancet*, March 10 and 17, 1906.

† The Cause of Coagulation of the Blood, p. 101 (quoted by Haward, *loc. cit.*).

Plainly there is a contradiction here; and either Haward or Horsley is incorrect in his deductions.

In conclusion, the following are the chief advantages of the method by sequestration in brain work of certain kinds:

(1) A diminution in amount of anaesthetic needed, with consequent relative safeguard against bleeding due to straining from subsequent vomiting, and against hernia cerebri; also against lowering of vital heat.

This operative analgesia is only obtainable with limbs well swollen and dusky. It is not always accomplished; but assuredly is in certain patients, the number studied as yet not being large enough for us to reach percentage conclusions.

(2) Ease of control of haemorrhage during operation because of lessened intravascular tension.

(3) A shortened operation because of a dryer field.

(4) Through lowered intracranial pressure consequent upon accumulation of blood elsewhere, there is lessened danger of sudden death from pressure upon the respiratory centre during work upon brain-tumor, or upon depressed fractures, etc.; and, too, just in proportion as there is bleeding, whether external or into the limbs, there is increased depth and frequency of breathing.

(5) More space between brain and brain-case, enabling the operator to work between, in removing old clots requiring curettage, or the separation of adhesions, etc., without risk of laceration of the brain surface.